

REPORT DOCUMENTATION PAGE				Form Approved OMB No. 0704-0188	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing this collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.					
1. REPORT DATE (DD-MM-YYYY) 6 Dec 2012		2. REPORT TYPE Consultative Letter		3. DATES COVERED (From – To) July 2012 – November 2012	
4. TITLE AND SUBTITLE Stewart Air National Guard Base, NY, C-5M Painting Refurbishment Assessment				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S) Batten, Timothy W., Capt, BSC, USAF				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) USAF School of Aerospace Medicine Department of Occupational and Environmental Health Consultative Services Division 2510 Fifth St. Wright-Patterson AFB, OH 45433-7913				8. PERFORMING ORGANIZATION REPORT NUMBER AFRL-SA-WP-CL-2012-0068	
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSORING/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION / AVAILABILITY STATEMENT Distribution A: Approved for public release; distribution is unlimited. Case Number: 88ABW-2012-6377, 6 Dec 2012					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT Major Scott Steigerwald, Command Bioenvironmental Engineer, Headquarters Air National Guard Bureau, requested the USAF School of Aerospace Medicine, Consultative Services Division provide a comprehensive exposure and risk assessment of the corrosion control process conducted on the C-5M in Building 101 at Stewart Air National Guard Base, NY. This facility was previously a fuels systems maintenance facility. At the time of this assessment, the facility was being converted for depot-type refurbishment of C-5M aircraft. A health risk assessment was accomplished 24-31 July 2012 to assess spray painting operations during a C-5M refurbishment. Neither the American Conference of Industrial Hygienists nor the Occupational Safety and Health Administration (OSHA) has specified an exposure limit for hexamethylene diisocyanate (HDI) oligomers; therefore, no OSHA or American Conference of Industrial Hygienists standard was exceeded. The U.S. Air Force School of Aerospace medicine recommends using the Oregon OSHA standard for risk assessment and management. Exposures to HDI oligomers exceeded the Oregon OSHA 8-hour time-weighted average and ceiling limit standards during chine cove painting processes. Exposures to HDI oligomers exceeded the action level, 50% of the Oregon OSHA standard, during flight deck painting operations despite using water-based polyurethane paints. Therefore, respiratory protection consisting of an air-purifying respirator with organic vapor cartridges and a high-efficiency particulate pre-filter should be continued by all painters within the restricted area. Additionally, contact hazards from isocyanate paints can adequately be mitigated through the continued practice of wearing cotton or Tyvek® coveralls and nitrile or neoprene gloves.					
15. SUBJECT TERMS Hexamethylene diisocyanate, HDI, isocyanate, monomers, oligomers, corrosion control, spray painting, C-5, Stewart ANGB					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT SAR	18. NUMBER OF PAGES 16	19a. NAME OF RESPONSIBLE PERSON Capt Timothy W. Batten
a. REPORT U	b. ABSTRACT U	c. THIS PAGE U			19b. TELEPHONE NUMBER (include area code)



DEPARTMENT OF THE AIR FORCE
USAF SCHOOL OF AEROSPACE MEDICINE (AFMC)
WRIGHT-PATTERSON AFB OH

6 December 2012

MEMORANDUM FOR HQ AIR NATIONAL GUARD BUREAU/SGPB
ATTN: MAJOR STEIGERWALD
3501 FETCHET AVE
JOINT BASE ANDREWS, MD 20762

FROM: USAFSAM/OEC
2510 Fifth Street
Wright-Patterson AFB, OH 45433-7913

SUBJECT: Consultative Letter AFRL-SA-WP-CL-2012-0068, Stewart Air National Guard
Base, NY, C-5M Painting Refurbishment Assessment

1. INTRODUCTION

a. *Purpose:* Major Steigerwald, Command Bioenvironmental Engineer, Headquarters Air National Guard Bureau, requested the U.S. Air Force School of Aerospace Medicine, Consultative Services Division (USAFSAM/OEC) provide a comprehensive exposure and risk assessment of the corrosion control process conducted on the C-5M in Building 101 at Stewart Air National Guard Base, NY. This facility was previously a fuels systems maintenance facility. At the time of this assessment, the facility was being converted for depot-type refurbishment of C-5M aircraft. A health risk assessment was accomplished 24-31 July 2012 to assess spray painting operations during a C-5M refurbishment.

b. *Health Hazard:* Isocyanates are a component of polyurethane paints. Exposure to isocyanates is irritating to the skin, mucous membranes, eyes, and respiratory tract. The most common adverse health outcome associated with isocyanate exposure is asthma due to sensitization. After sensitization, any exposure, even to levels below the occupational exposure limit, can produce an asthmatic response that may be life threatening.¹

c. *Survey Personnel:*

- (1) Capt Timothy Batten, Industrial Hygiene Consultant, USAFSAM/OEC
- (2) TSgt Gene Moll, Industrial Hygiene Technician, USAFSAM/OEC
- (3) SSgt Sang Lee, Industrial Hygiene Technician, USAFSAM/OEC
- (4) SrA Dillon Davis, Bioenvironmental Technician, 105 MDG/SGPB

¹ **National Institute for Occupational Safety and Health.** *A Summary of Health Hazard Evaluations: Issues Related to Occupational Exposure to Isocyanates, 1989 to 2002.* Cincinnati, OH: NIOSH Publications Dissemination, January 2004. DHHS (NIOSH) Publication No. 2004-116.

d. *Personnel Contacted:*

- (1) MSgt Thomas Rampley, 105 MDG/SGPB
- (2) SSgt Michael Carson, 105 MXS/MXR
- (3) SSgt Michael Fleming, 105 MXS/MXR
- (4) SSgt Alan Tierney, 105 MXS/MXR
- (5) SSgt Abby Bronson, 105 MXS/MXR

e. *Equipment:*

- (1) Bios DC-1 Dry Cal calibrator
- (2) SKC Organic Vapors, Passive Sampler. Product Code: 575-001 (passive sampler)
- (3) SKC Airchek XR5000 sampling pumps. Product Code: 210-5003K5D (air sample pump)
- (4) SKC ISO-CHEK™, filter cassette. Product Code: 225-9022A (Iso-Chek™ sampler)
- (5) SKC Filter Cassette Holder. Product Code: 225-1 (cassette holder)
- (6) SKC Anasorb, Sorbent Charcoal Tube. Product Code: 226-01 (charcoal tube sampler)
- (7) SKC Low Flow Adapter Kit (tube holder)
 - (a) Constant pressure controller (#224-26-CPC)
 - (b) Single adjustable low flow holder (#224-26-01)
 - (c) Size A protective tube cover (#210-500)

2. SURVEY PROCEDURES/DISCUSSION: The team from USAFSAM/OEC accomplished air sampling from 25-26 July and 30-31 July for chine coves (Figure 1) and flight deck (Figure 2) refurbishment processes, respectively. The two processes were unique from each other in that the chine coves are in a naturally ventilated open cargo area yet use isocyanate paints, while the flight deck area has restricted air flow yet uses water-based polyurethane paints.

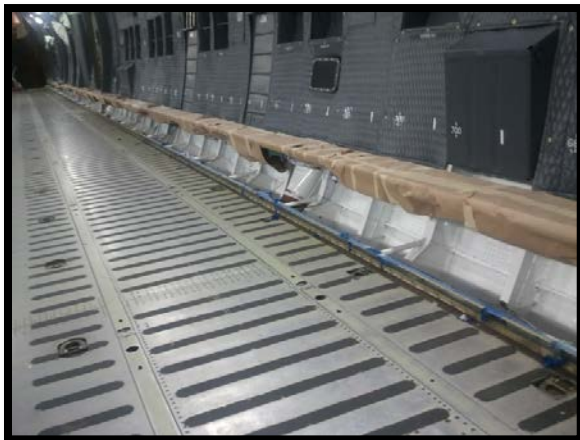


Figure 1: Chine coves, pictured here in white



Figure 2: Flight deck

a. Air samples were collected using two methods simultaneously. During chine cove painting, the Iso-Chek™ sampler and the passive sampler were used. During flight deck painting, the Iso-Chek™ sampler and the charcoal tube sampler were used. The two sampling techniques were selected to quantify both the principal hazard of the isocyanates as well as the secondary concern with various volatile organic constituents of the painting processes. The Iso-Chek™ method is the USAFSAM-recommended sample method for quantifying both the monomer as well as the oligomer species of the hexamethylene diisocyanate (HDI)². The volatile organics were assessed using the passive sampler for chine cove painting and the charcoal tube sampler for the flight deck painting.

b. Due to a limited number of Iso-Chek™ samplers, only one representative painter was assessed using the Iso-Chek™ method per work shift. Additional Iso-Chek™ sampling by the local Bioenvironmental Engineering Flight could add statistical confidence to the hazard characterization. The Iso-Chek™ sampler was clipped to the shoulder of the painter within the breathing zone, while either a passive sampler or a charcoal tube sampler was clipped to the opposite shoulder of all four painters. The cassettes were held in place with a cassette holder, while the charcoal tube samplers were held in place with a tube holder in line with a low flow reducer (Figure 3). The flow rate for the Iso-Chek™ sampler was set at 1 liter per minute (Lpm). The flow rate for the charcoal tube sampler was set at 0.2 Lpm.



Figure 3: Iso-Chek™ and charcoal tube samplers

c. According to the material safety data sheet for the Deft polyurethane paint, the gloss white poly resin hardener contains HDI and volatile organic compounds, including 1,2,4-trimethylbenzene, 2-pentanone, methyl isobutyl ketone, and n-butyl acetate. According to the material safety data sheet for the Sherwin-Williams Jet Flex paint, the gray water-based polyurethane contains a proprietary nonisocyanate two-part polymer in addition to organic

² **Batten, Timothy W.** *Base Level Guide for the Occupational Exposure to Isocyanates*. Wright-Patterson AFB, OH: U.S. Air Force School of Aerospace Medicine, 2012. AFRL-SA-WP-SR-2012-0003.

compounds, including 2-butoxyethanol, butyl carbitol, and methylpyrrolidone. Laboratory analyses of the Iso-Chek™ samplers and the charcoal tube samplers were performed by Bureau Veritas, while passive samplers were analyzed by USAFSAM's analytical chemistry lab.

d. During the time of the chine cove survey, ample natural ventilation was provided by having both the forward and aft loading bay doors of the C-5 open and parallel to the open front and back hangar doors. These conditions provided variable cross-ventilation through the cargo compartment of the C-5. The outside hangar doors are kept closed during winter months. During flight deck sampling, an exhaust ventilation system was employed (Figure 4). However, only two of the three ducts were used, thereby significantly limiting the efficacy of the local exhaust due to the massive loss at the point of connection.



Figure 4: Local exhaust for flight deck painting operations

e. The schedule for painting the C-5M lasts about 3 weeks. Spray painting with isocyanates on board the aircraft is limited to the ramp edges, chine coves, and escape hatch. Spray painting with water-based polyurethane paint was conducted in the flight deck and crew area. This exposure assessment examined two shifts of exposure to the isocyanate paints and two shifts of exposure to the flight deck painting area.

f. *Assessment Limitations:* On 31 July, HDI monomer and oligomer sample numbers 7DXG, 7DXH, and 7DXI were lost due to a fault in the sample collection pump. Sampling data showed that the HDI monomer is typically below the limit of detection for this paint; however, the oligomer phase of HDI in this paint has the potential to be of concern. Unfortunately, the loss of these samples makes the evaluation of the HDI oligomer inconclusive for this day. Additional Iso-Chek™ sampling by the local Bioenvironmental Engineering Flight would add statistical confidence to the hazard characterization. The American Industrial Hygiene Association (AIHA) suggests a minimum of six total sampling events per process to begin to calculate a

similar exposure group's exposure profile for a routine hazard³. Fortunately, adequate personal protective equipment is used as a general practice for painting; therefore, there is no anticipated health concern provided these protective measures are continued.

3. FINDINGS AND RECOMMENDATIONS: The focus of the exposure assessment primarily centered on the monomer and oligomer phase of HDI, considered to be the most hazardous constituent in the painting process; however, other potentially hazardous paint ingredients were included in the comprehensive assessment as secondary concerns. The findings and recommendations in this letter are specific to the ambient conditions at the time of the exposure assessment.

a. The concentrations of the HDI monomers during the isocyanate painting applications were below the occupational and environmental exposure limit (OEEL) of 0.034 mg/m³ when compared to the 8-hour time weighted average (8-h TWA) for each of the 4 days sampled. However, due to the loss of samples from a pump malfunction and limiting Iso-ChekTM sampling to only one representative worker each day, the confidence in the exposure assessment would be further strengthened by additional Iso-ChekTM sampling events. Collecting six total samples in accordance with the AIHA sampling strategy would aid in calculating the exposure profile for each of the processes assessed during this site visit⁴.

b. The concentration of the HDI oligomers exceeded the OEEL of 0.5 mg/m³. Also, the ceiling limit of 1 mg/m³ for the HDI oligomer was often exceeded.

c. Secondary constituents of concern were found to be well below their respective exposure limits (see Table 1). Further details of these exposures can be found in Attachments 1 and 2.

d. The cross-ventilation provided by open hangar doors likely enhances ventilation controls. Therefore, weather conditions requiring the hangar doors to be kept closed should initiate a reassessment of these painting processes in a follow-up exposure assessment to account for this seasonal variability.

e. The minimum required respiratory protection during spray painting is an air-purifying respirator with organic vapor cartridges and N-95 particulate pre-filters. While exposures to HDI oligomers were often exceeded, respirator protection meets the minimum requirements and is within the protection factor of the full face respirator in accordance with Air Force Occupational Safety and Health Standard 48-137, Attachment 2.

³ **American Industrial Hygiene Association. 1998.** *A Strategy for Assessing and Managing Occupational Exposures*. [ed.] J. Mulhausen and J. Damiano. Fairfax : AIHA, 1998. Vol. 2nd.

⁴ **American Industrial Hygiene Association.** *A Strategy for Assessing and Managing Occupational Exposures*. [ed.] J. Mulhausen and J. Damiano. Fairfax, VA: AIHA, 1998. Vol. 2nd.

f. When painting in the flight deck, attach the third local exhaust duct for a third painter or cap the opening of the unused duct so that the flow of ventilation is maximized at the two painters' positions. A box fan could be placed near the access door to increase air movement if stagnant zones are a concern.

Table 1. Air Sampling Standards

Substance (Synonym)	8-h TWA		Other Limits (mg/m³)	Source Authority ^a
	Limit (mg/m³)	Limit (ppm)		
Primary Health Concerns				
HDI Monomer	0.034	0.005	---	ACGIH
HDI Oligomer	0.5	---	1.0 ceiling	Oregon OSHA
Secondary Health Concerns				
2-Butoxyethanol	96	20	---	ACGIH
n-Butyl Acetate	710	150	950 STEL ^b	ACGIH
Butyl Carbitol (2-(2-butoxyethoxy)ethanol)	100	---	100 peak	Germany MAK
Hexone (methyl isobutyl ketone)	82	20	300 STEL	ACGIH
n-Methyl-2-pyrrolidone	41	10	---	AIHA WEEL
2-Pentanone (methyl propyl ketone)	700	200	880 STEL	U.S. OSHA
1,2,4-Trimethylbenzene	125	25	---	ACGIH

^aACGIH = American Conference of Industrial Hygienists; OSHA = Occupational Safety and Health Administration; WEEL = Workplace Environmental Exposure Levels.

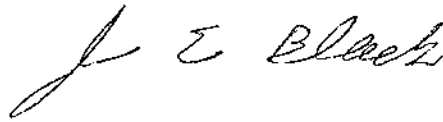
^bSTEL = short-term exposure limit.

4. CONCLUSIONS:

a. Neither ACGIH nor OSHA has specified an exposure limit for HDI oligomers; therefore, no OSHA or ACGIH standard was exceeded. USAFSAM⁵ recommends using the Oregon OSHA standard for purposes of risk assessment and management. Exposures to HDI oligomers exceeded the Oregon OSHA 8-h TWA and ceiling limit standards during chine cove painting processes. Exposures to HDI oligomers exceeded the action level, 50% of the Oregon OSHA standard, during flight deck painting operations despite using water-based polyurethane paints. Therefore, respiratory protection consisting of an air-purifying respirator with organic vapor cartridges and a high-efficiency particulate pre-filter should be continued by all painters within the restricted area. Additionally, contact hazards from isocyanate paints can adequately be mitigated through the continued practice of wearing cotton or Tyvek® coveralls and nitrile or neoprene gloves.

⁵ **Batten, Timothy W.** *Base Level Guide for the Occupational Exposure to Isocyanates*. Wright-Patterson AFB, OH: U.S. Air Force School of Aerospace Medicine, 2012. AFRL-SA-WP-SR-2012-0003.

b. Thank you for affording USAFSAM/OEC the opportunity to assist you. Please direct additional questions to Capt Timothy Batten, DSN 798-3296, or timothy.batten@wpafb.af.mil.

A handwritten signature in black ink that reads "J E Black". The signature is written in a cursive, flowing style.

JON E. BLACK, Maj, USAF, BSC
Chief, Bioenvironmental Engineering Consulting Branch

2 Attachments

1. Summary Results
2. Detailed Sampling Results

Attachment 1 Summary Results

Table A1-1. Summary Results, Chine Cove Painting, 25 July 2012

Worker	Hazard	Sampling Duration (min)	Mass (µg)	Conc. (mg/m ³)	8-h TWA OEEL (mg/m ³)	8-h TWA (mg/m ³)	Over Limit (Yes/No)
CARSON	2-Pentanone	252	21.2	5.35	700	2.8	No
	Methyl Isobutyl Ketone	252	<7.54	<2.20 ^a	82	0.6	No
	n-Butyl Acetate	252	<8.28	<2.49 ^a	710	0.7	No
	Trimethylbenzene	252	<8.33	<2.73 ^a	125	0.7	No
FLEMING	2-Pentanone	305	1010	212	700	134.7	No
	Methyl Isobutyl Ketone	305	64.8	15.6	82	9.9	No
	n-Butyl Acetate	305	124	30.9	710	19.6	No
	Trimethylbenzene	305	<8.33	<2.26 ^a	125	0.7	No
	HDI Monomer	165	3.12	0.0285	0.034	0.01	No
	HDI Oligomer	165	2470	14.9	0.5	5.13	Yes
TIERNEY	2-Pentanone	290	<7.61	<1.67 ^a	700	0.5	No
	Methyl Isobutyl Ketone	290	<7.54	<1.91 ^a	82	0.5	No
	n-Butyl Acetate	290	<8.28	<2.16 ^a	710	0.7	No
	Trimethylbenzene	290	<8.33	<2.38 ^a	125	0.7	No
BRONSON	2-Pentanone	313	11.6	2.37	700	1.5	No
	Methyl Isobutyl Ketone	313	<7.54	<1.77 ^a	82	0.6	No
	n-Butyl Acetate	313	219	53.1	710	34.6	No
	Trimethylbenzene	313	<8.33	<2.20 ^a	125	0.7	No

^aConcentration was below the laboratory's lower limit of detection and was adjusted using the division by two (x/2) method.

Table A1-2. Summary Results, Chine Cove Painting, 26 July 2012

Worker	Hazard	Sampling Duration (min)	Mass (µg)	Conc. (mg/m ³)	8-h TWA OEEL (mg/m ³)	8-h TWA (mg/m ³)	Over Limit (Yes/No)
CARSON	2-Pentanone	225	<7.61	<2.15 ^a	700	0.5	No
	Methyl Isobutyl Ketone	225	<7.54	<2.46 ^a	82	0.6	No
	n-Butyl Acetate	225	<8.28	<2.79 ^a	710	0.7	No
	Trimethylbenzene	225	<8.33	<3.06 ^a	125	0.7	No
FLEMING	2-Pentanone	230	36.7	10.2	700	4.9	No
	Methyl Isobutyl Ketone	230	<7.54	<2.41 ^a	82	0.6	No
	n-Butyl Acetate	230	<8.28	<2.73 ^a	710	0.7	No
	Trimethylbenzene	230	<8.33	<2.99 ^a	125	0.7	No
TIERNEY	2-Pentanone	237	663	178	700	87.9	No
	Methyl Isobutyl Ketone	237	45.4	14.1	82	7.0	No
	n-Butyl Acetate	237	94.8	30.3	710	15.0	No
	Trimethylbenzene	237	<8.33	<2.91 ^a	125	0.7	No
	HDI Monomer	75	1.58	0.021	0.034	0.003	No
	HDI Oligomer	75	1110	14.6	0.5	2.28	Yes
BRONSON	2-Pentanone	192	716	233	700	93.2	No
	Methyl Isobutyl Ketone	192	50.4	19.3	82	7.7	No
	n-Butyl Acetate	192	173	68.1	710	27.2	No
	Trimethylbenzene	192	<8.33	<3.59 ^a	125	0.7	No
	HDI Monomer	105	1.64	0.031	0.034	0.007	No
	HDI Oligomer	105	1520	14.4	0.5	3.15	Yes

^aConcentration was below the laboratory's lower limit of detection and was adjusted using the division by two (x/2) method.

Table A1-3. Summary Results, Flight Deck Painting, 30 July 2012

Worker	Hazard	Sampling Duration (min)	Mass (µg)	Conc. (mg/m ³)	8-h TWA OEEL (mg/m ³)	8-h TWA (mg/m ³)	Over Limit (Yes/No)
CARSON	2-Butoxyethanol	162	12	0.37	96	0.12	No
	Butyl Carbitol	162	180	5.7	100	1.92	No
	Methylpyrrolidone	162	110	3.3	41	1.11	No
	HDI Monomer	105	0.7	0.007	0.034	0.002	No
	HDI Oligomer	105	22.1	0.216	0.5	0.047	No
FLEMING	2-Butoxyethanol	275	1600	28	96	16.04	No
	Butyl Carbitol	275	26	0.48	100	0.28	No
	Methylpyrrolidone	275	12	0.22	41	0.13	No
TIERNEY	2-Butoxyethanol	209	<2	<0.048 ^a	96	0.01	No
	Butyl Carbitol	209	<3	<0.072 ^a	100	0.016	No
	Methylpyrrolidone	209	<3	<0.072 ^a	41	0.016	No
BRONSON	2-Butoxyethanol	203	13	0.31	96	0.13	No
	Butyl Carbitol	203	190	4.7	100	1.99	No
	Methylpyrrolidone	203	110	2.8	41	1.18	No

^aConcentration was below the laboratory's lower limit of detection and was adjusted using the division by two (x/2) method.

Table A1-4. Summary Results, Flight Deck Painting, 31 July 2012

Worker	Hazard	Sampling Duration (min)	Mass (µg)	Conc. (mg/m ³)	8-h TWA OEEL (mg/m ³)	8-h TWA (mg/m ³)	Over Limit (Yes/No)
CARSON	2-Butoxyethanol	199	24	0.60	96	0.25	No
	Butyl Carbitol		310	7.8	100	3.23	No
	Methylpyrrolidone		160	4.0	41	1.66	No
FLEMING	2-Butoxyethanol	237	16	0.33	96	0.16	No
	Butyl Carbitol		230	4.8	100	2.37	No
	Methylpyrrolidone		130	2.8	41	1.38	No
	HDI Monomer	135	0.9	0.007	0.034	0.002	No
	HDI Oligomer	135	168.9	1.081	0.5	0.304	No
TIERNEY	2-Butoxyethanol	279	18	0.32	96	0.19	No
	Butyl Carbitol		300	5.3	100	3.08	No
	Methylpyrrolidone		160	2.9	41	1.69	No
BRONSON	2-Butoxyethanol	298	<2	<0.034 ^a	96	0.01	No
	Butyl Carbitol		24	0.40	100	0.25	No
	Methylpyrrolidone		13	0.22	41	0.14	No

^aConcentration was below the laboratory's lower limit of detection and was adjusted using the division by two (x/2) method.

Attachment 2 Detailed Sampling Results

Table A2-1. Passive Results, Chine Cove Painting, 25 July 2012

Worker	Hazard	Sampling Duration (min)	Mass (µg)	Conc. (mg/m ³)	8-h TWA OEEL (mg/m ³)	8-h TWA (mg/m ³)	Over Limit (Yes/No)
CARSON	2-Pentanone	252	21.2	5.35	700	2.8	No
	Methyl Isobutyl Ketone		<7.54	<2.20 ^a	82	0.6	No
	n-Butyl Acetate		<8.28	<2.49 ^a	710	0.7	No
	Trimethylbenzene		<8.33	<2.73 ^a	125	0.7	No
FLEMING	2-Pentanone	305	1010	212	700	134.7	No
	Methyl Isobutyl Ketone		64.8	15.6	82	9.9	No
	n-Butyl Acetate		124	30.9	710	19.6	No
	Trimethylbenzene		<8.33	<2.26 ^a	125	0.7	No
TIERNEY	2-Pentanone	290	<7.61	<1.67 ^a	700	0.5	No
	Methyl Isobutyl Ketone		<7.54	<1.91 ^a	82	0.5	No
	n-Butyl Acetate		<8.28	<2.16 ^a	710	0.7	No
	Trimethylbenzene		<8.33	<2.38 ^a	125	0.7	No
BRONSON	2-Pentanone	313	11.6	2.37	700	1.5	No
	Methyl Isobutyl Ketone		<7.54	<1.77 ^a	82	0.6	No
	n-Butyl Acetate		219	53.1	710	34.6	No
	Trimethylbenzene		<8.33	<2.20 ^a	125	0.7	No

^aConcentration was below the laboratory's lower limit of detection and was adjusted using the division by two (x/2) method.

Table A2-2. Iso-Chek™ HDI Monomer Results, Chine Cove Painting, SSgt Fleming, 25 July 2012

Sample Number	Sampling Duration (min)	Mass (µg)	Conc. (mg/m ³)	8-h TWA OEEL (mg/m ³)	Over Limit (Yes/No)
7CDO ^a	15	<0.2	<0.013 ^a	0.034	No
7CDP	15	0.42	0.028	0.034	No
7CDQ	15	0.37	0.024	0.034	No
7CDR	15	0.41	0.027	0.034	No
7CDS	15	0.3	0.020	0.034	No
7CDT	15	0.23	0.015	0.034	No
7CDU ^a	15	<0.2	<0.013 ^a	0.034	No
7CDV	15	0.30	0.020	0.034	No
7CDW	15	0.30	0.020	0.034	No
7CDX	15	0.31	0.021	0.034	No
7CDY	15	0.28	0.018	0.034	No
Process Totals	165	3.12	0.0285	0.034	No
8-h TWA	480	3.12	0.0098	0.034	No

^aConcentration was below the laboratory's lower limit of detection and was adjusted using the division by two (x/2) method.

Table A2-3. Iso-Chek™ HDI Oligomer Results, Chine Cove Painting, SSgt Fleming, 25 July 2012

Sample Number	Sampling Duration (min)	Mass (µg)	Conc. (mg/m ³)	8-h TWA OEEL (mg/m ³)	Ceiling OEEL (mg/m ³)	Over Limit (Yes/No)
7CDO	15	170	11	0.5	1.0	Yes
7CDP	15	230	15	0.5	1.0	Yes
7CDQ	15	220	15	0.5	1.0	Yes
7CDR	15	200	13	0.5	1.0	Yes
7CDS	15	300	20	0.5	1.0	Yes
7CDT	15	220	15	0.5	1.0	Yes
7CDU	15	120	8.2	0.5	1.0	Yes
7CDV	15	300	20	0.5	1.0	Yes
7CDW	15	240	16	0.5	1.0	Yes
7CDX	15	270	18	0.5	1.0	Yes
7CDY	15	200	13	0.5	1.0	Yes
Process Totals	165	2470	14.9	0.5	1.0	Yes
8-h TWA	480	2470	5.13	0.5	1.0	Yes

Table A2-4. Passive Results, Chine Cove Painting, 26 July 2012

Worker	Hazard	Sampling Duration (min)	Mass (µg)	Conc. (mg/m ³)	8-h TWA OEEL (mg/m ³)	8-h TWA (mg/m ³)	Over Limit (Yes/No)
CARSON	2-Pentanone	225	<7.61	<2.15 ^a	700	0.5	No
	Methyl Isobutyl Ketone		<7.54	<2.46 ^a	82	0.6	No
	n-Butyl Acetate		<8.28	<2.79 ^a	710	0.7	No
	Trimethylbenzene		<8.33	<3.06 ^a	125	0.7	No
FLEMING	2-Pentanone	230	36.7	10.2	700	4.9	No
	Methyl Isobutyl Ketone		<7.54	<2.41 ^a	82	0.6	No
	n-Butyl Acetate		<8.28	<2.73 ^a	710	0.7	No
	Trimethylbenzene		<8.33	<2.99 ^a	125	0.7	No
TIERNEY	2-Pentanone	237	663	178	700	87.9	No
	Methyl Isobutyl Ketone		45.4	14.1	82	7.0	No
	n-Butyl Acetate		94.8	30.3	710	15.0	No
	Trimethylbenzene		<8.33	<2.91 ^a	125	0.7	No
BRONSON	2-Pentanone	192	716	233	700	93.2	No
	Methyl Isobutyl Ketone		50.4	19.3	82	7.7	No
	n-Butyl Acetate		173	68.1	710	27.2	No
	Trimethylbenzene		<8.33	<3.59 ^a	125	0.7	No

^aConcentration was below the laboratory's lower limit of detection and was adjusted using the division by two (x/2) method.

Table A2-5. Iso-Chek™ HDI Monomer Results, Chine Cove Painting, SSgt Tierney, 26 July 2012

Sample Number	Sampling Duration (min)	Mass (µg)	Conc. (mg/m ³)	8-h TWA OEEL (mg/m ³)	Over Limit (Yes/No)
7CRL	15	0.24	0.016	0.034	No
7CRM	15	0.34	0.023	0.034	No
7CRN	15	0.33	0.022	0.034	No
7CRO	15	0.45	0.030	0.034	No
7CRP	15	0.22	0.015	0.034	No
Process Totals	75	1.58	0.021	0.034	No
8-h TWA	480	1.58	0.003	0.034	No

Table A2-6. Iso-Chek™ HDI Oligomer Results, Chine Cove Painting, SSgt Tierney, 26 July 2012

Sample Number	Sampling Duration (min)	Mass (µg)	Conc. (mg/m ³)	8-h TWA OEEL (mg/m ³)	Ceiling OEEL (mg/m ³)	Over Limit (Yes/No)
7CRL	15	220	14	0.5	1.0	Yes
7CRM	15	210	14	0.5	1.0	Yes
7CRN	15	190	12	0.5	1.0	Yes
7CRO	15	170	11	0.5	1.0	Yes
7CRP	15	320	22	0.5	1.0	Yes
Process Totals	75	1110	14.6	0.5	1.0	Yes
8-h TWA	480	1110	2.28	0.5	1.0	Yes

Table A2-7. Iso-Chek™ HDI Monomer Results, Chine Cove Painting, SSgt Bronson, 26 July 2012

Sample Number	Sampling Duration (min)	Mass (µg)	Conc. (mg/m ³)	8-h TWA OEEL (mg/m ³)	Over Limit (Yes/No)
7CRQ	15	0.26	0.017	0.034	No
7CRR	15	0.23	0.016	0.034	No
7CRS	15	0.37	0.025	0.034	No
7CRT	15	0.30	0.020	0.034	No
7CRU ^a	15	<0.2	<0.013 ^a	0.034	No
7CRV	15	0.28	0.019	0.034	No
7CSB ^a	15	<0.2	<0.013 ^a	0.034	No
Process Totals	105	1.64	0.031	0.034	No
8-h TWA	480	1.64	0.007	0.034	No

^aConcentration was below the laboratory's lower limit of detection and was adjusted using the division by two (x/2) method.

Table A2-8. Iso-Chek™ HDI Oligomer Results, Chine Cove Painting, SSgt Bronson, 26 July 2012

Sample Number	Sampling Duration (min)	Mass (µg)	Conc. (mg/m ³)	8-h TWA OEEL (mg/m ³)	Ceiling OEEL (mg/m ³)	Over Limit (Yes/No)
7CRQ	15	350	23	0.5	1.0	Yes
7CRR	15	220	15	0.5	1.0	Yes
7CRS	15	110	7.6	0.5	1.0	Yes
7CRT	15	190	12	0.5	1.0	Yes
7CRU	15	110	7.2	0.5	1.0	Yes
7CRV	15	290	19	0.5	1.0	Yes
7CSB	15	250	17	0.5	1.0	Yes
Process Totals	105	1520	14.4	0.5	1.0	Yes
8-h TWA	480	1520	3.15	0.5	1.0	Yes

Table A2-9. Charcoal Tube Results, Flight Deck Painting, 30 July 2012

Worker	Hazard	Sampling Duration (min)	Mass (µg)	Conc. (mg/m ³)	8-h TWA OEEL (mg/m ³)	8-h TWA (mg/m ³)	Over Limit (Yes/No)
CARSON	2-Butoxyethanol	162	12	0.37	96	0.12	No
	Butyl Carbitol		180	5.7	100	1.92	No
	Methylpyrrolidone		110	3.3	41	1.11	No
FLEMING	2-Butoxyethanol	275	1600	28	96	16.04	No
	Butyl Carbitol		26	0.48	100	0.28	No
	Methylpyrrolidone		12	0.22	41	0.13	No
TIERNEY	2-Butoxyethanol	209	<2	<0.048 ^a	96	0.01	No
	Butyl Carbitol		<3	<0.072 ^a	100	0.016	No
	Methylpyrrolidone		<3	<0.072 ^a	41	0.016	No
BRONSON	2-Butoxyethanol	203	13	0.31	96	0.13	No
	Butyl Carbitol		190	4.7	100	1.99	No
	Methylpyrrolidone		110	2.8	41	1.18	No

^aConcentration was below the laboratory's lower limit of detection and was adjusted using the division by two (x/2) method.

Table A2-10. Iso-Chek™ HDI Monomer Results, Flight Deck Painting, SSgt Carson, 30 July 2012

Sample Number	Sampling Duration (min)	Mass (µg)	Conc. (mg/m ³)	8-h TWA OEEL (mg/m ³)	Over Limit (Yes/No)
7DW8 ^a	15	<0.2	<0.013 ^a	0.034	No
7DW9 ^a	15	<0.2	<0.013 ^a	0.034	No
7DWA ^a	15	<0.2	<0.013 ^a	0.034	No
7DWB ^a	15	<0.2	<0.013 ^a	0.034	No
7DWC ^a	15	<0.2	<0.013 ^a	0.034	No
7DWD ^a	15	<0.2	<0.013 ^a	0.034	No
7DWE ^a	15	<0.2	<0.013 ^a	0.034	No
Process Totals	105	0.7	0.007	0.034	No
8-h TWA	480	0.7	0.002	0.034	No

^aConcentration was below the laboratory's lower limit of detection and was adjusted using the division by two (x/2) method.

Table A2-11. Iso-Chek™ HDI Oligomer Results, Flight Deck Painting, SSgt Carson, 30 July 2012

Sample Number	Sampling Duration (min)	Mass (µg)	Conc. (mg/m ³)	8-h TWA OEEL (mg/m ³)	Ceiling OEEL (mg/m ³)	Over Limit (Yes/No)
7DW8	15	16	1.1	0.5	1.0	Yes
7DW9	15	1.2	0.083	0.5	1.0	No
7DWA	15	1.1	0.074	0.5	1.0	No
7DWB ^a	15	<1	<0.067 ^a	0.5	1.0	No
7DWC ^a	15	<1	<0.067 ^a	0.5	1.0	No
7DWD	15	1.5	0.10	0.5	1.0	No
7DWE	15	1.3	0.087	0.5	1.0	No
Process Totals	105	22.1	0.216	0.5	1.0	No
8-h TWA	480	22.1	0.047	0.5	1.0	No

^aConcentration was below the laboratory's lower limit of detection and was adjusted using the division by two (x/2) method.

Table A2-12. Charcoal Tube Results, Flight Deck Painting, 31 July 2012

Worker	Hazard	Sampling Duration (min)	Mass (µg)	Conc. (mg/m ³)	8-h TWA OEEL (mg/m ³)	8-h TWA (mg/m ³)	Over Limit (Yes/No)
CARSON	2-Butoxyethanol	199	24	0.60	96	0.25	No
	Butyl Carbitol		310	7.8	100	3.23	No
	Methylpyrrolidone		160	4.0	41	1.66	No
FLEMING	2-Butoxyethanol	237	16	0.33	96	0.16	No
	Butyl Carbitol		230	4.8	100	2.37	No
	Methylpyrrolidone		130	2.8	41	1.38	No
TIERNEY	2-Butoxyethanol	279	18	0.32	96	0.19	No
	Butyl Carbitol		300	5.3	100	3.08	No
	Methylpyrrolidone		160	2.9	41	1.69	No
BRONSON	2-Butoxyethanol	298	<2	<0.034 ^a	96	0.01	No
	Butyl Carbitol		24	0.40	100	0.25	No
	Methylpyrrolidone		13	0.22	41	0.14	No

^aConcentration was below the laboratory's lower limit of detection and was adjusted using the division by two (x/2) method.

Table A2-13. Iso-Chek™ HDI Monomer Results, Flight Deck Painting, SSgt Fleming, 31 July 2012

Sample Number	Sampling Duration (min)	Mass (µg)	Conc. (mg/m ³)	8-h TWA OEEL (mg/m ³)	Over Limit (Yes/No)
7DXD ^a	15	<0.2	<0.013 ^a	0.034	No
7DXE ^a	15	<0.2	<0.013 ^a	0.034	No
7DXF ^a	15	<0.2	<0.013 ^a	0.034	No
7DXG ^{a,b}	15	<0.2	<0.013 ^a	0.034	No
7DXH ^{a,b}	15	<0.2	<0.013 ^a	0.034	No
7DXI ^{a,b}	15	<0.2	<0.013 ^a	0.034	No
7DXJ ^a	15	<0.2	<0.013 ^a	0.034	No
7DXK ^a	15	<0.2	<0.013 ^a	0.034	No
7DXL ^a	15	<0.2	<0.013 ^a	0.034	No
Process Totals	135	0.9	0.007	0.034	No
8-h TWA	480	0.9	0.002	0.034	No

^aConcentration was below the laboratory's lower limit of detection and was adjusted using the division by two (x/2) method.

^bPump fault, sample was lost, results inconclusive.

Table A2-14. Iso-Chek™ HDI Oligomer Results, Flight Deck Painting, SSgt Fleming, 31 July 2012

Sample Number	Sampling Duration (min)	Mass (µg)	Conc. (mg/m ³)	8-h TWA OEEL (mg/m ³)	Ceiling OEEL (mg/m ³)	Over Limit (Yes/No)
7DXD	15	30	2.0	0.5	1.0	Yes
7DXE	15	43	2.8	0.5	1.0	Yes
7DXF	15	6.4	0.43 ^a	0.5	1.0	No ^a
7DXG ^{a,b}	15	<1	<0.067 ^{a,b}	0.5	1.0	No ^a
7DXH ^{a,b}	15	<1	<0.067 ^{a,b}	0.5	1.0	No ^a
7DXI ^{a,b}	15	<1	<0.067 ^{a,b}	0.5	1.0	No ^a
7DXJ	15	39	1.1	0.5	1.0	Yes
7DXK	15	26	1.8	0.5	1.0	Yes
7DXL	15	23	1.5	0.5	1.0	Yes
Process Totals	135	168.9	1.081	0.5	1.0	Yes
8-h TWA	480	168.9	0.304	0.5	1.0	No

^aPump fault, sample was lost, results inconclusive.

^bConcentration was below the laboratory's lower limit of detection and was adjusted using the division by two (x/2) method.